

Wildlife Use of Water Sources along boundaries at Walnut Canyon and Wupatki National Monuments

This report is an overview of key results from research supported by WNPA. For detailed analyses and comprehensive discussion, thesis manuscripts will be available at Northern Arizona University library archives and the Flagstaff National Park Service archives.

Project Synopsis

Little is known regarding the effects of different kinds of upland free water on behaviors, populations and communities of vertebrates in arid and semi-arid environments, including wildlife that use parks. In light of declines in natural waters, construction and maintenance of artificial water sources on the Colorado Plateau has resulted in a novel situation of well-distributed persistent waters in otherwise arid and semi-arid regions. Because free water limits most wildlife species in dry environments (Mares et al. 1995), the provisioning of water in excess of natural conditions may affect distributions and behaviors of animals adapted to dry environments. At a finer scale, use has likely shifted from ephemeral natural waters to more widespread and persistent artificial sources. However, we know little about how selection of different water sources by different wildlife species affects structure and function of wildlife communities that use parks. In response, we developed an exploratory study designed to describe and explain spatial and temporal patterns of wildlife, expressly mid- to large-size vertebrates, visitation to natural and artificial water sources along the boundaries of Wupatki (WUPA) and Walnut Canyon (WACA) National Monuments in northern Arizona. These NPS monuments differ biophysically, which afforded the opportunity to study how wildlife responded to differences in water availability, physiognomy, and species community composition at natural and artificial waters.

For approximately two years we camera-trapped wildlife visits to naturally occurring and artificially created water sources and used multiple regression models to explain variation in water source visitation patterns of the most commonly detected species, focusing on the significance of free water availability, climate variables, habitat structure, and intra- and interspecific interactions. Because of limited prior information, and the field nature of this study, explanations are necessarily tentative. Many facets of this study are exploratory and descriptive. Emerging patterns and related inferences constituted a major part of this study's value. As such, this study provides a basis for subsequent formulation and testing of hypotheses specific to wildlife-water issues on the Colorado Plateau and in other arid environments. Focal species included, but were not limited to, predators (including puma [*Puma concolor*], black bear [*Ursus americanus*], coyote [*Canis latrans*], gray fox [*Urocyon cinereoargenteus*], bobcat [*Felis rufus*], badger [*Taxidea taxus*] and skunks), ungulates (including elk [*Cervis elaphus*], mule deer [*Odocoileus hemionus*], pronghorn [*Antilocapra americana*]) and birds of prey (raptors and ravens [*Corvus corax*]).

We focused on addressing interrelated research hypotheses, and developed conceptual models (Engelbart 1962) to structure the approach to addressing these hypotheses, drawing on prior research synopsized above (Figure 1). These models were tacit

hypotheses regarding system structure and function, also of potential help to wildlife managers interpreting wildlife-related dynamics organized around upland free water (see Figure 2). Based on these conceptual models, we identified a set of candidate explanatory statistical models appropriate to each wildlife response, with separate models for WUPA and WACA. We differentiated models based on spatial explanatory variables [radial visibility, distance to cover, and canopy cover, the presence of potential predator and competitors, and surface water consistency] from those based on temporal explanatory variables [temperature and precipitation, surface and preformed water availability, and the presence of other species] and considered different individual species and species guilds appropriate to whether the models were for WUPA or WACA.

Results and Discussion

Our analyses indicated significant differences in water source selection among commonly detected species. As expected, animal abundance and species richness at WUPA was greater at artificial waters (Table 1). Patterns of animal visits to water sources at WUPA can be partially attributed to differences in water availability between natural and artificial waters. In the arid lands of WUPA, species were more abundant and diverse at artificial waters, negligibly visiting natural waters except during colder periods when waters were more persistent. Animals in WUPA typically use natural waters when opportunistically available, but actively seek out the more perennial artificial water sources more consistently. The scarcity of natural free water inside WUPA may drive many water-dependent species, specifically pronghorn, across the boundary in search of more persistent waters. Considering the regularity of dry natural waters at WUPA, pronghorn likely need access to more permanent sources of water during drier periods, which additionally coincides with critical reproductive times such as late gestation and calving (Bright and Van Riper 1999). Further, forage succulence highly correlated with temperature rather than precipitation (although increases in temperatures correlated with the advent of monsoonal rains), consequently affected pronghorn visits to surface water. As forage succulence decreased pronghorn visits to artificial surface water increased. Pronghorn are likely the most affected species at WUPA with regards to spring (April-June) forage availability and accessing surface water.

At WACA, animals had continuous access to both natural and artificial waters, and therefore greater opportunity to choose between natural and artificial water sources. Because of this relative evenness between natural and artificial water persistence, water availability was not as significant a factor in wildlife water selection in WACA as in WUPA, and likely did not influence wildlife movements across WACA boundaries. Species richness was similar between natural and artificial waters, with differences in species diversity between natural and artificial waters owing to dissimilar compositions of predator versus prey species at these water source types (Table 2). In general, predator species at both WUPA and WACA were better able to opportunistically move between natural and artificial waters. As in WUPA, ungulates at WACA relied on preformed water more often during warmer periods, especially during spring and monsoons when forage succulence was greatest, Ungulates generally visited artificial waters more often when forage succulence was low, suggesting that elk and mule deer may partially satisfy

water needs with preformed water when sufficiently available. The nearly exclusive selection of artificial waters by ungulates at both WUPA and WACA may be attributable to the ready availability of artificial waters beyond park boundaries.

In addition to biased water preferences observed by ungulates, ravens and raptors also solely focused on artificial waters in WUPA and selected natural waters in WACA considerably less than artificial waters. Ravens were the most abundant species at artificial waters at both WUPA and WACA (Tables 1 and 2). Raven water selection in the arid lands of WUPA was likely attributable to the greater distribution of perennial artificial waters and a dearth of persistent natural waters. The presence of artificial water sources may facilitate high raven populations by providing water during periods of low or no precipitation when natural waters are lacking. Ravens populations have been showed to be positively correlated with available water (Boarman and Berry 1995), increasing reproductive success with decreasing proximity to human created waters (Kristan and Boarman 2001, Webb 2001), and increasing upwards of 1500% in some dryland areas (Boarman 1993). The exceptional delivery of artificial waters across the drylands of northern Arizona has allowed ravens to expand their range into habitat previously uninhabited by such large numbers of ravens.

Physiognomic parameters at water sources significantly varied between WUPA and WACA, with subsequent differences in wildlife richness between natural and artificial waters at their respective study areas. Visibility factors at water sources significantly influenced community structure and wildlife selection of different water sources. Pronghorn selection of water sources was likely influenced by visibility parameters, typified by the open grassland stock tanks. Pronghorn very rarely visited natural water sources in shrub basin habitat, possibly because of restricted visibility. Upland pronghorn at WUPA exploit the persistent grassland stock tanks that provide relatively unhindered visibility. At WUPA coyotes were the top common predator and frequented all monitored water sources, including low, moderate, and high visibility waters. As such, visibility parameters and related predation risks and opportunities were not limiting factors in coyote water source selection, and were generally more affected by opportunistic water availability at WUPA. Bobcats at WUPA preferred low visibility water sources with more cover, benefiting bobcats by providing stalking habitat. At water sources in WACA, bobcats and especially coyotes may have avoided waters with limited visibility to evade predation. Unlike WUPA, coyotes at WACA were more affected by visibility at water sources, and exclusively visited high visibility waters along woodland edges. Bobcats as well generally selected higher visibility waters more often than waters with constricted visibility. This divergence may be related to the differences in predator structure between WUPA and WACA. These mesopredators may be altering their use of space and activity patterns in response to larger predators, i.e. cougars that frequent canyon habitat in WACA.

In WACA, elk and mule deer almost exclusively visited high visibility artificial water sources (Figure 3), abundantly found in open ponderosa pine and juniper woodlands, and avoided lower visibility natural waters where predation threats, i.e. cougars, assumingly increase. In this study, cougars regularly visited artificial waters. Although models

showed that cougars were influenced more by climate variations than prey availability at artificial waters, mule deer generally avoided water sources more frequented by cougars. These results are in line with DeStephano et al. (2000) that speculated that most large predators most likely come to water sites to drink rather than to hunt, and that [large ungulate] kills are more likely opportunistic.

From a community-level perspective, we observed diverse interspecific relationships among predators than commonly frequented water sources. Bobcats and coyotes exhibit broad and overlapping diets depending on season and availability of prey base. At WUPA, bobcat visits tended to decline as coyote visits increased, suggesting that coyotes may somewhat displace bobcats. Further, coyotes in WUPA, especially when present in multiple numbers, may out-compete bobcats and badgers at water sources. Relative to bobcats, which were mostly nocturnal, activity patterns of coyotes at artificial water sources were more evenly distributed, including significant diurnal activity. Our results are consistent with other studies (Neal and Sacks 2001) that found that coyotes and bobcats [and badgers] appear to use the same [water] resources independently, with little negative interference. Shifts in diel activities by bobcats and badgers may tender this spatial relationship between predators by temporally partitioning resources. Wittier and deCalesta (1986) found little competition between coyotes and bobcats when prey populations were high. Plausibly wide availability of artificial water sources may support high densities of small and large prey, and may reduce the competitive interference between these species.

Gray fox may target water sources more broadly than coyotes and bobcats at WACA. Durant (1998) reported that spatial avoidance among species may lessen the effects of interspecific competition. Gray fox tended to advantageously visit waters that may reduce potential predation or harassment from other mesopredators, primarily coyotes. These waters were typically of low visibility and close cover, generally avoided by coyotes. Interestingly, gray fox showed little aversion to waters routinely visited by cougars. This spatial association between gray fox and cougars might be attributable to gray fox adopting nocturnal diel patterns at overlapping water sources whereas cougars were more crepuscular. Because of the ability to exploit several niches, gray fox is probably the most water-adept predator at WACA, broadly visiting all monitored water sources.

Addressing the Management of Upland Waters around Parks

The shift in the natural range of water availability has affected the variation of species composition that naturally occurs in water limited park ecosystems. As evident in this study, artificial waters play a critical role in water selection for upland wildlife in semi-arid park ecosystems. The importance of seasonal natural variations in water availability has been supplanted by perennial artificial sources of water. Many wildlife species have opted for the widely distributed artificial water sources in favor of the historically sparse and ephemeral natural waters. Extensive perennial waters have likely affected interspecific relationships and community structure. Animals able to exploit abundant water sources can endure dryland environments that were previously water limited. Some species have likely benefited from increased water availability whereas others have not.

Little is known about how expanding ungulate or predator populations affect other species. In northern Arizona, intensely managed game species such as elk, certainly have benefited from artificial water sources. Non-target species such as ravens and coyotes have likely exploited increases in water availability and expanded into new habitats with unknown consequences.

The threat to species inhabiting arid regions where artificial waters serve as the primary source of water could be pronounced as birds in particular congregate around these water sources. The National Park Service has confirmed WNV-positive mosquito pools (NPS 2004) near areas where artificial water sources are abundant. During this study, bird species at WUPA was 8 times greater at artificial waters compared to natural waters (Table 1), including extensive use by ravens. Although no studies have attempted to draw a parallel between raven water use and the spread of WNV, raven exploitation of artificial waters across arid environments could precipitate the proliferation WNV transmission impacting park wildlife.

Despite the apparent importance of rangeland water availability to upland pronghorn populations, few studies have adequately addressed pronghorn-cattle competition at water sources. The ability to efficiently access artificial stock waters frequented by cattle may be important to sustaining healthy populations of upland pronghorn. We observed temporal partitioning, and partial exclusion during periods of high cattle occupancy, at artificial waters of pronghorn by cattle occupying the same range (Figure 4). Pronghorn at WUPA avoided water sources when occupied by cattle. As cattle occupancy increased, pronghorn water visits sharply decreased (Figure 5). Maintaining water availability and accessibility at select water sources during critical reproductive periods may benefit declining or recovering pronghorn populations. Managers should be aware of the potentially adverse effects on pronghorn fitness from cattle occupying the same range, and consider options of incorporating existing artificial waters into recovery plans to elude further declines in upland pronghorn populations.

Artificial waters have become an integral component in wildlife management and may benefit several species in the near term (see Rosenstock et al. 1999). Aside from effects on single species, artificial water sources are a potentially powerful means for managing conservation of biodiversity in arid and semi-arid zones (James et al 2000) and can have other effects on native fauna which also need to be considered as management decisions are made (James et al. 1999). Providing water sources may be a strategic management tool but must be viewed critically regarding effects on distribution of wild animals. Currently, few directives exist regarding distributions of artificial waters across arid landscapes. The management challenge is to develop a balanced representation of habitats across the landscape that is influenced to different degrees by water sources, so that the requirements of all species are accommodated.

Graphs and Figures

Figure 1. Flow chart of the influential biotic and abiotic parameters involved in wildlife selection of natural and artificial water sources

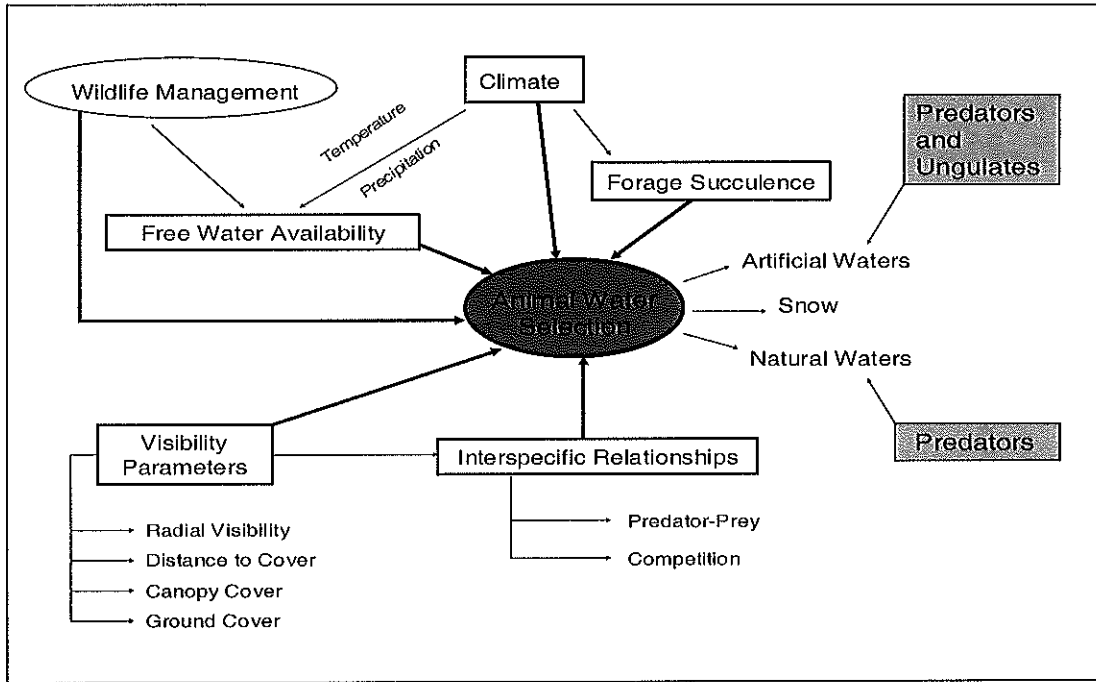


Figure 2. Flow chart of community structure at natural and artificial water sources based on spatial organization of competing species and physiognomic variables

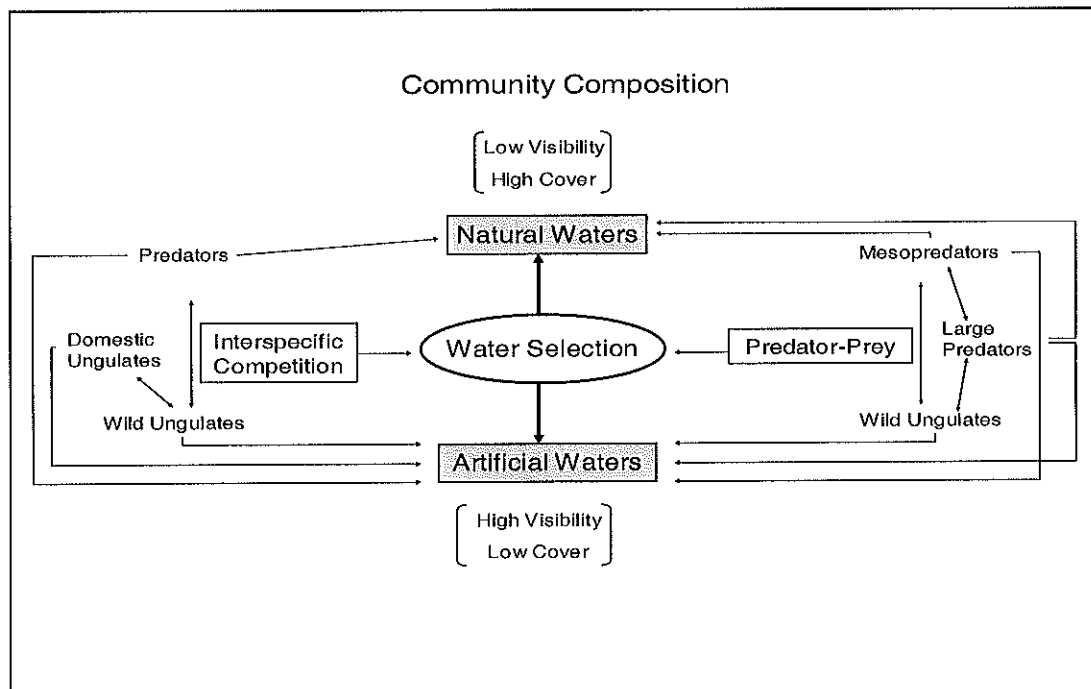


Table 1. Distribution of detections of target species and total hours monitored at natural and artificial water sources at Wupatki.

Wupatki Species	Natural detections	Artificial detections
puma	0	2
coyote	56	212
badger	0	39
bobcat	28	104
gray fox	0	1
Predator species	84	358
elk	0	17
pronghorn	7	403
mule deer	63	350
jackrabbit	3	5
cottontail	2	0
Prey species	75	775
golden eagle	1	40
red-tailed hawk	0	27
sharpshinned hawk	0	12
turkey vulture	0	21
great horned owl	0	3
pygmy/elf owl	0	21
Raptor species	1	124
Raven	2	1329
Total detections	162	2707
Total hours monitored	29300	26930

Table 2. Distribution of detections of target species and total hours monitored at natural and artificial water sources at Walnut Canyon.

Walnut Canyon Species	Natural detections	Artificial detections
puma	11	15
black bear	37	22
coyote	1	55
badger	0	1
bobcat	26	28
gray fox	205	179
skunk	26	4
Predator Species	306	304

mule deer	0	70
elk	9	636
pronghorn	0	0
javelina	4	30
wild turkey	0	23
Prey Species	13	759
goshawk	2	9
red-tailed hawk	0	1
sharp-shinned hawk	1	58
turkey vulture	16	14
golden eagle	2	0
Raptor Species	21	82
Raven	44	150
Total detections	384	1295
Total hours monitored	25680	21251

Figure 3. Graph of elk and mule deer detections at natural and artificial water sources in Walnut Canyon. Red bar indicates detections at artificial waters and green bar indicates detections at natural waters.

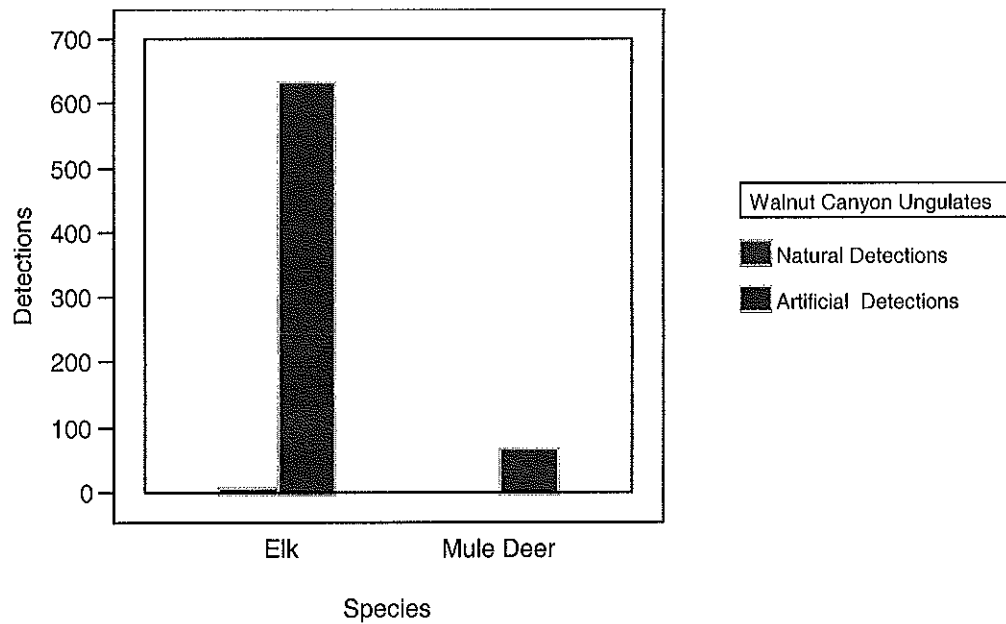


Figure 4. Graph of pronghorn detections as a function of cattle presence. Yellow line indicates pronghorn detections and brown bars indicate cattle presence as an index of % capacity at water sources.

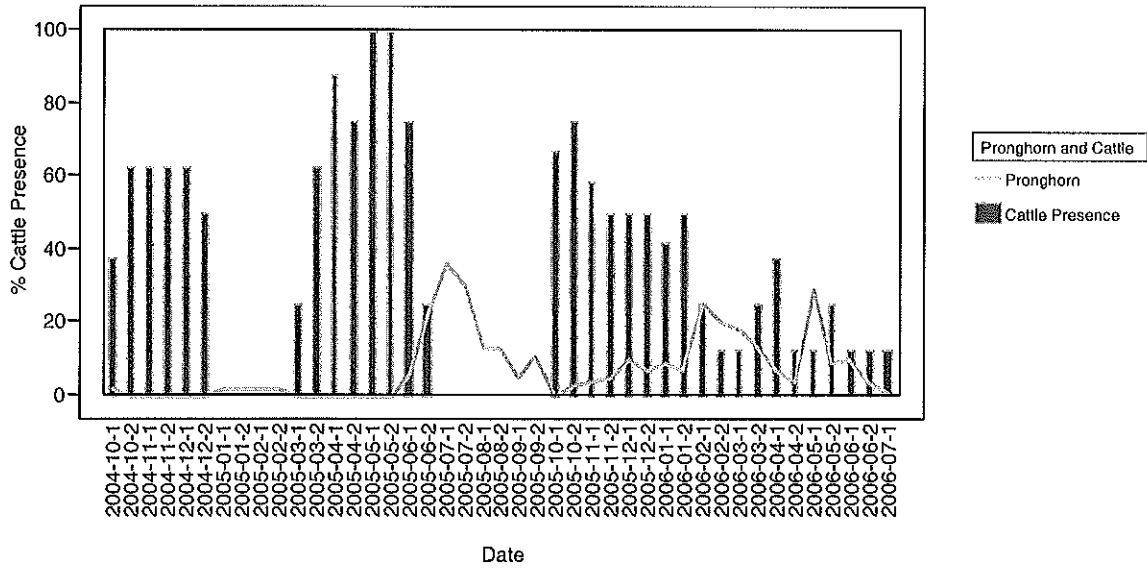


Figure 5. Graph of linear fit ($R^2 = .740$, $p = <.0001$) of pronghorn detections as predicted by % cattle presence; Red line indicates linear fit of regression with 95% confidence intervals.

